

## Anatomy of New Zealand species of the family Sphaeriidae (Bivalvia, Eulamellibranchia)

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### Abstract

Mantle edge, gills, brood pouches and nephridia are described in *Musculium novaezelandiae* (Deshayes 1854), *Pisidium hodgkini* (Suter, 1905) and *P. novaezelandiae* Prime, 1862. Affinity of the first species to the subgenus *Sphaerinova* Iredale and placement of the second one in the subgenus *Afropisidium* Kuiper is confirmed by anatomical characters. The problem of identity of *P. novaezelandiae* and *P. casertanum* (Poli, 1791) is discussed.

Key words: Sphaeriidae, New Zealand

### Introduction

Small freshwater bivalves of the family Sphaeriidae are known from New Zealand since Deshayes (1854). Four endemic species were distinguished in earlier reviews (Suter, 1913; Powell, 1957): *Sphaerium novaezelandiae* Deshayes 1854, *Pisidium novaezelandiae* Prime, 1862, *P. aucklandicum* (Suter, 1913) and *Pisidium hodgkini* (Suter, 1905). Kuiper (1966) placed the *Sphaerium* species in the subgenus *Sphaerinova* Iredale, 1943 and *P. hodgkini* in the subgenus *Afropisidium* Kuiper, 1962. He also synonymized the two remaining species with *P. casertanum* (Poli, 1791) considered a cosmopolitan species. *S. novaezelandiae* was transferred to the genus *Musculium* by Heard (1977). As considered now, the New Zealand fauna of sphaeriids consists of three species - one of the genus *Musculium* and two of *Pisidium*.

Until now only the shell characters of New Zealand species are known. However, significance of anatomical characters was shown by Odhner (1929) and confirmed by recent investigations in the Palaearctic region (Korniushev, 1992) and Africa (Korniushev, 1995). In the light of these data, anatomical investigation of sphaeriids is rather important for better understanding of their taxonomic affinities and improving classification.

In 1996, I had an opportunity to study some museum collections of New Zealand sphaeriids representing all three species known from this region. This investigation allowed to check anatomical characters of these species and provides some data on their affinities.

### Material and Methods

Specimens for dissection were obtained from the Australian Museum, Sydney (AMS) (seven lots, all collected by Winston F. Ponder) and National Museum of New Zealand, Wellington (NMNZ) (three lots of different collectors). Collection details are provided with the respective descriptions.

Gross anatomy and nephridium characters were studied under the dissecting microscope, then mantle edge and gills were extracted, stained by

aqueous eosine and Grenacher's carmine, respectively, and embedded in Canada balsam. Arrangement of ctenidium filaments and mantle muscles was studied in these slides. All drawings were made with camera lucida.

## Results

### *Musculium novaezelandiae* (Deshayes, 1854) (Figs. 1-2)

*Material:* Backwaters of Cluth River at Lowburn, coll. by J.R.Greenfield 30 February 1967, M131677 (NMNZ). Goulter River west of Mt.Patriarch, south of Nelson, 41°36'S, 173°9'E, in pools and small streams, collected 10 December 1982 by Winston F. Ponder, C317034 (AMS).

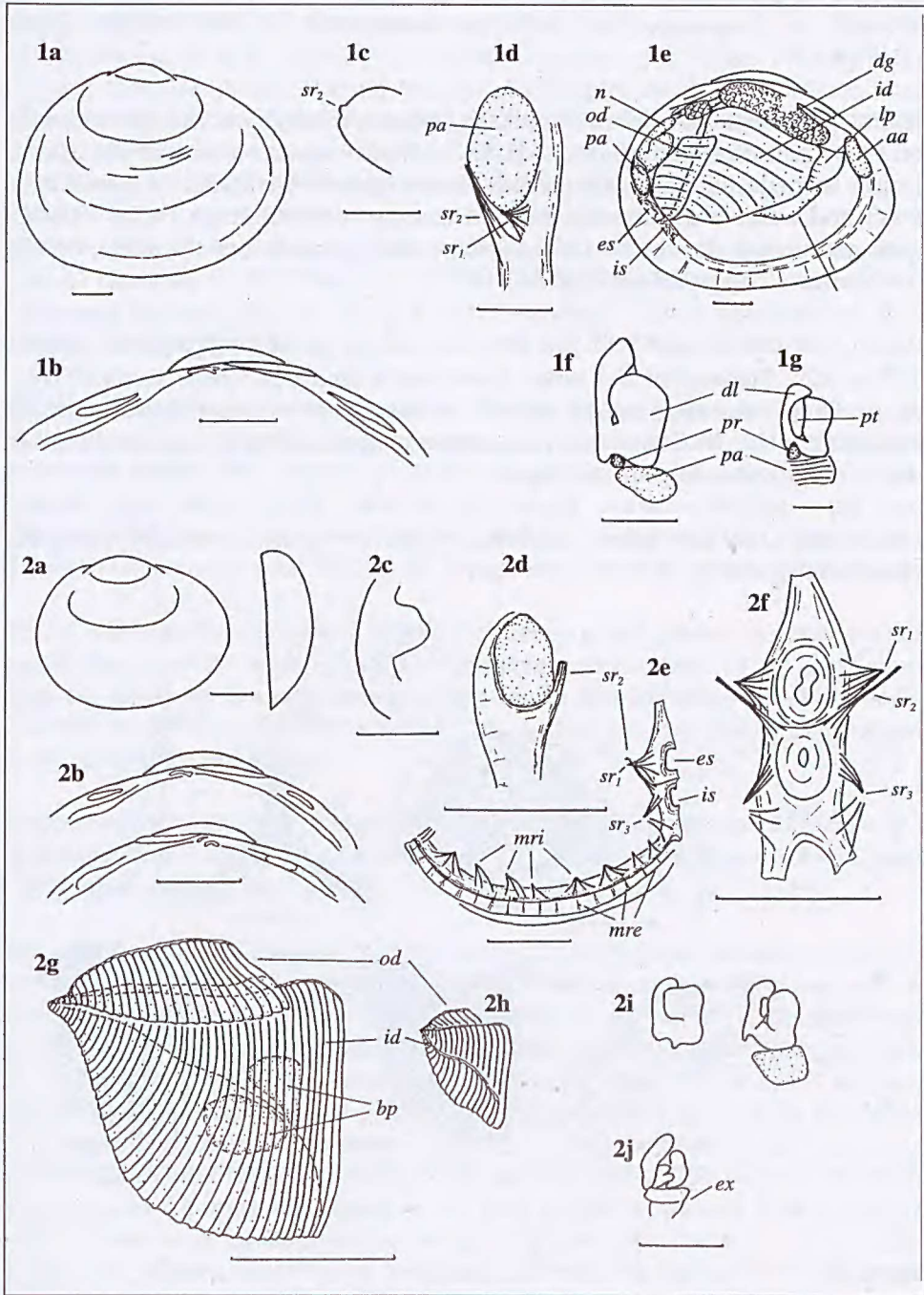
*Mantle:* Two tubular siphons. Exhalant (upper) siphon with one pair of retractors. Inhalant (lower) siphon with two pairs of muscles (Fig. 2f); upper retractors short and thin, tightly adjoining posterior adductor muscles (Fig. 1d, 2d), their scars not separated (Fig. 1c). Mantle edge rather thick and broad, both inner and outer radial mantle muscles well developed. Inner radial muscles arranged in seven bundles evenly distributed along mantle edge, four anterior bundles being strongest (Fig. 2e).

*Gills:* Outer demibranch present but rather small (height about  $\frac{1}{3}$  inner demibranch height), with two lamellae (Fig. 2g). In young specimens, outer demibranch begins at fifth filament of inner one (Fig. 2h). Free embryos and two brood pouches, each composed of two or three filaments, present in each gill; from 2 to 13 embryos per pouch found.

*Nephridium:* Both closed (with pericardial part not visible from outside) and open nephridia observed (Fig. 1f, 1g, 2i), open type more frequent in studied material. Dorsal lobe relatively broad. Excretory sac small, without internal valve (Fig. 2j); funnel long and narrow.

**Figures 1 - 2.** (see page facing)

*Musculium novaezelandiae* (Deshayes). 1. Cluth River at Lowburn, NMNZ: a - right valve from outside, b - hinge of this valve, c - posterior muscle scars, d - siphonal retractors laterally, e - gross anatomy, f,g - nephridia dorsally; 2. Goulter River, AMS: a - right valve from outside and posterior end, b - hinge, c - posterior muscle scars, d - siphonal retractors laterally, e - musculature of the mantle edge, f - siphonal retractors from the inner side, g - ctenidium of adult specimen from outside, h - ctenidium of the young specimen from inside, i - nephridia dorsally, j - nephridium ventrally; aa - anterior adductor, bp - brood pouch, dg - digestive gland, dl - dorsal lobe of nephridium, es - exhalant siphon, ex - excretory sac, f - foot, id - inner demibranch of ctenidium, is - inhalant siphon, ll - lateral loop of nephridium, lp - labial palps, n - nephridium, od - outer demibranch of ctenidium, mri - interior radial mantle muscles, mre - exterior radial mantle muscles, pa - posterior adductor, pr - pedal retractor, sr1 - retractors of the exhalant siphon, sr2 - upper retractors of the inhalant siphon or their scars, sr3 - lower retractors of the inhalant siphon. Scale bar=1 mm.



*Pisidium novaezelandiae* Prime, 1862.

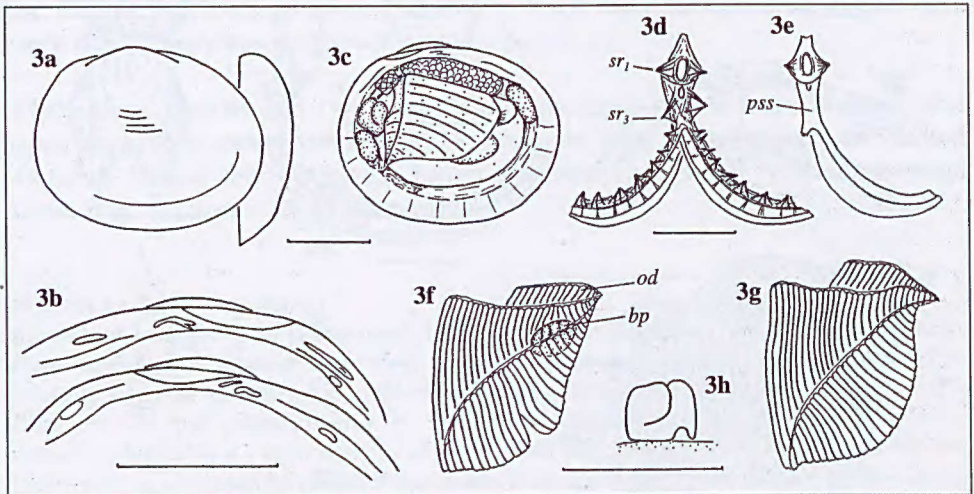
(Fig. 3)

*Material:* Approximately 10 km SE of Te Aroha, north-east of Hamilton, 37°38'S, 175°40'E, in seepage, collected 31 December 1982 by W.F. Ponder (AMS C317028).

*Mantle:* Only exhalant siphon tubular, inhalant one being simple opening with only one pair of retractors (Fig. 3d). Pre-siphonal suture somewhat elongated, length  $\frac{1}{5}$  pedal slit length (Fig. 3d,e). Mantle edge rather thick and broad, both inner and outer radial mantle muscles well developed. Inner radial muscles arranged in six to seven rather strong and concentrated bundles evenly distributed along pedal slit (Fig. 3d).

*Gills:* Outer demibranch with one lamella, with its anterior edge placed against 11<sup>th</sup> or 12<sup>th</sup> filament of the inner demibranch (four specimens studied) (Fig. 3f, g). Only one brood pouch formed in lower part of inner demibranch by 5 filaments (Fig. 3f). The studied specimens contained small pouches, therefore it was not possible to count embryos.

*Nephridium:* Only closed type observed. Dorsal lobe square, completely covering pericardial part (Fig. 3h).



**Figure 3.**

*Pisidium novaezelandium* Prime, near Te Aroha, AMS: a - right valve from outside and posterior end, b - hinge, c - gross anatomy, d - musculature of the mantle edge, e - mantle edge of the other specimen, f, g - ctenidia from inside, h - nephridium dorsally; pss - presiphonal suture, other abbreviations as in the Figs.1-2. Scale bar=1 mm.

*Pisidium hodgkini* (Suter, 1905)  
(Fig.4-7)

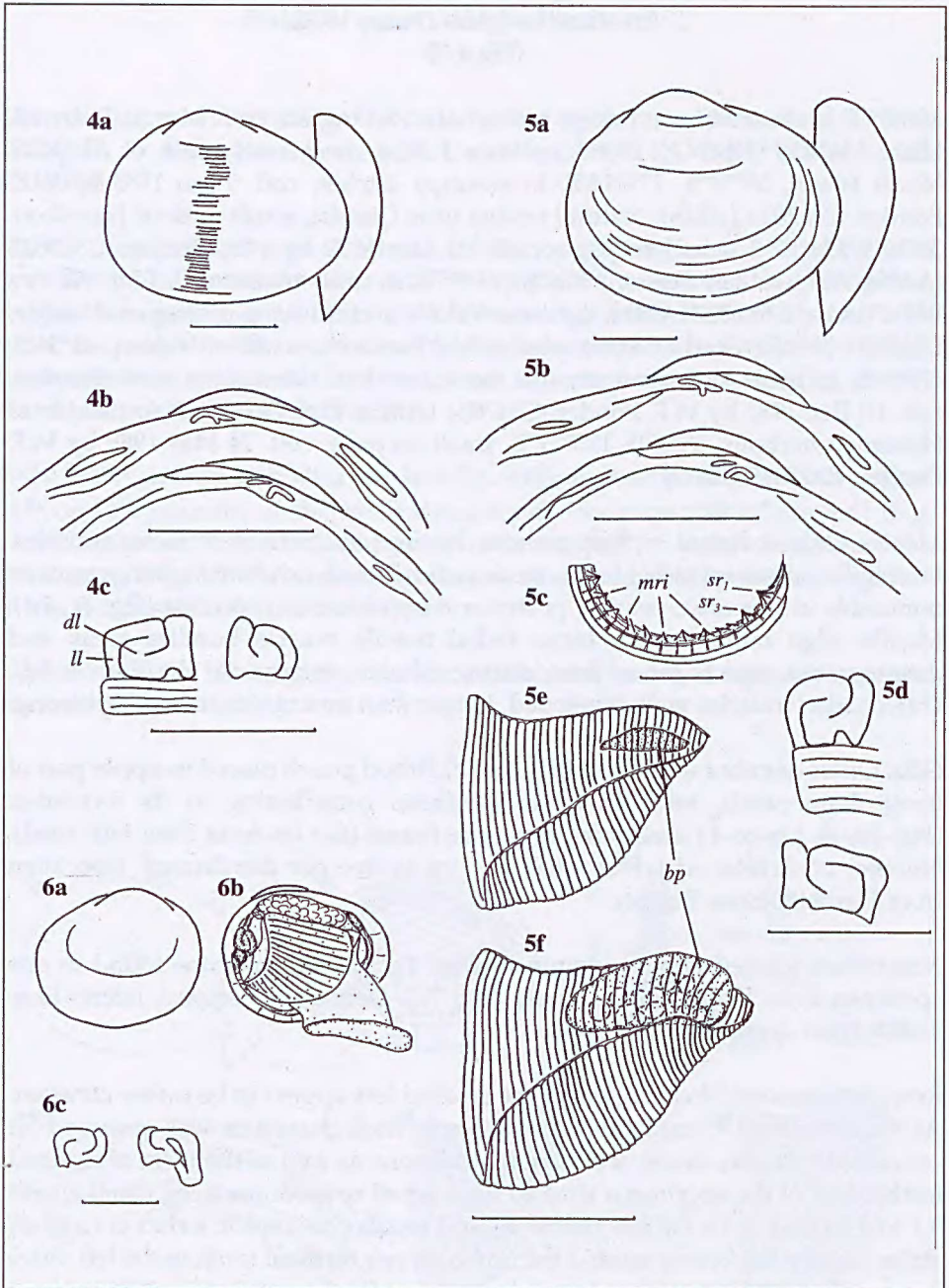
*Material:* Makara stream, bridge by turnoff, Wellington, coll. May 1976 by M. Hine, M47438 (NMNZ); Herekino State Forest, main road south of Ahipora, North Island, 35°13'S 173°12'E, in swampy ditches, coll. 9 Jan 1983 by W.F. Ponder, C317024 (AMS); Natural bridge near Diripiri, south-west of Hamilton, 38°13'S 174°52'E, small seepages, coll. 21 Dec 1982 by W.F. Ponder, C317025 (AMS); Waipoa State Forest, 35°57'S 173°35'E, in small trickle, coll. 7 Jan 1983 by W.F. Ponder, C317027 (AMS); the same locality and collector, in long road trickle, C317031 (AMS); Goulter River west of Mt. Patriarch, south of Nelson, 41°36'S, 173°9'E, in pools and small streams associated with *Musculium novaezelandiae*, coll. 10 Dec 1982 by W.F. Ponder, C317034 (AMS); Pine Hill road, south side of Hokianga harbour, 35°33'S 173°27'E, small seepage, coll. 24 Mar 1989 by W.F. Ponder, C317035 (AMS).

*Mantle:* Only exhalant siphon present, having one pair of retractor muscles. Intersiphonal suture rather long, weak rudiments of exhalant siphon retractors noticeable in this area, nearby posterior termination of pedal slit (Fig. 5c, 7d). Mantle edge rather broad. Inner radial mantle muscle bundles weak and disintegrated, nine to ten of them distinguishable along pedal slit (Fig. 5c, 7d). Outer radial muscles well developed, longer than inner ones and rather strong.

*Gills:* Outer demibranch absent (Fig.6b, 7c). Brood pouch placed in upper part of inner demibranch, with 13 to 18 filaments contributing to its formation (Fig. 5e, f). Up to 14 embryos per pouch found (the lot from Pine Hill road). Number of developed larvae smaller - up to five per demibranch (specimen from Herekino State Forest).

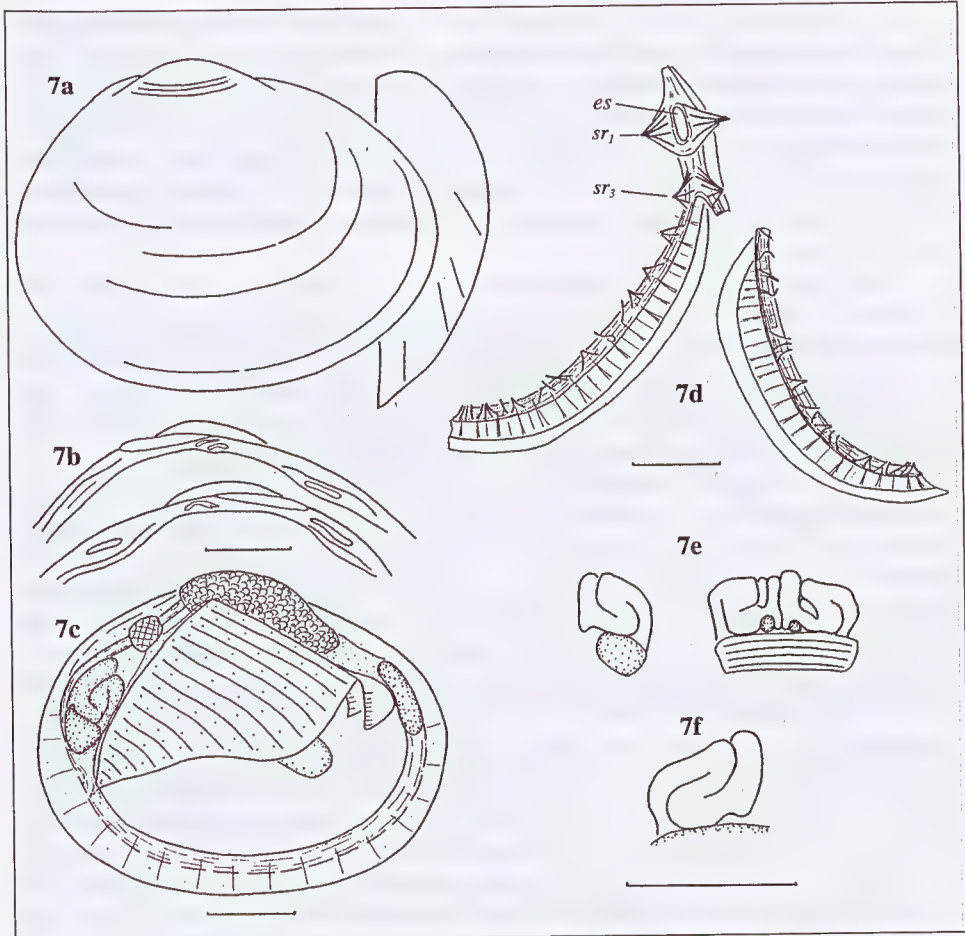
*Nephridium:* Closed type predominant (Fig. 4c, 5d, 7f); open one found in one specimen from Waipoa State Forest (Fig. 7e). Dorsal lobe square, lateral loop visible from dorsal side.

*Remarks:* Anatomical characters of the studied lots appear to be rather constant. At the same time, considerable variability in shell characters was observed. It concerns shell size, shape, and surface sculpture, as well as the form of cardinal teeth. Most of the specimens studied were small or medium sized (shell length 3.1 to 3.6 mm), with narrow umbones and regular concentric striation (coarser striae usually noticeable around the umbo); inner cardinal tooth in the left valve is strongly bent (sometimes dome-shaped), cardinal tooth in the right valve is deeply cleft, with diverging branches (Fig. 4a, b; 5a, b; 6a). The larger form (shell length up to 5.2 mm) was found in the road trickle in Waipoa State Forest. It differed also in its broader umbo, weak sculpture (only the striae around the umbo were present) and slightly bent cardinal teeth (Fig. 7a,b). It is notable, that these characters were not pronounced in the specimens from another habitat (small trickle) in the same locality, probably because of their younger age.



**Figures 4 - 6.**

*Pisidium hodgkini* (Suter). 4. Herekino State Forest, AMS: a - right valve from outside and posterior end, b - hinge, c - nephridia dorsally; 5. Pine Hill road, AMS: a - right valve from outside and posterior end, b - hinge, c - musculature of the mantle edge, d - nephridia dorsally, e, f - ctenidia from inside (with the subsequent stages of brood pouch development); 6. Wellington, NMNZ: a - left valve from outside, b - gross anatomy, c - nephridia dorsally; abbreviations as in the Figs.1-2. Scale bar=1 mm.



**Figure 7.**

*Pisidium hodgkini*, large form, Waipoa State Forest, AMS: a - right valve from outside and posterior end, b - hinge, c - gross anatomy, d - musculature of the mantle edge, e, f - nephridia dorsally; abbreviations as in the Figs.1-2. Scale bar=1 mm.

### Discussion

Anatomical data provided here are rather important for defining generic and subgeneric status of New Zealand sphaeriids. Good generic characters of *Musculium*, namely relatively small excretory sac without internal valve and long funnel of nephridium, were provided by Mansur and Meier-Brook (1992). These characters were also observed in *Musculium novaezelandiae*, confirming its generic placement. As shown by Korniushev (1995), the type species of *Sphaerinova*, *Musculium tasmanicum* (Tenison Woods 1870), is characterized by rather small and weak upper retractors of the inhalant siphons. This state is supposed to be an apomorphy, while it is not found in *Sphaerium*, which may serve a suitable outgroup for *Musculium* (Mansur & Meier-Brook, 1992). In New Zealand species, reduction of siphonal muscles is even more pronounced and thus its close affinity to the Australian *Sphaerinova* is quite probable. As shown

by Korniushev (1995, 1998a), this character is also shared by a South African and several South American species of *Musculium*, thus we have a group of similar species distributed on different continents. Monophyly of the group might be supposed, but the evidence for it (weak siphonal retractors) is not sufficient. One cannot exclude that similar reduction of siphonal musculature took place independently in different clades. Therefore, decisions on species composition of *Sphaerinova* and subgeneric belonging of the New Zealand *Musculium* are not provided here.

The grounds for synonymization of *Pisidium novaezelandiae* with *P. casertanum* (Kuiper, 1966) seem to be insufficient. The New Zealand species is nearer in many characters to *P. tasmanicum* Tenison Woods, 1876, which is now considered a distinct species (Kuiper, 1983), than to European *P. casertanum*. The following characters are observed in the specimens available for this study (Fig. 3a, b), in specimens from New Zealand figured by Kuiper (1966), and in *P. tasmanicum* figured by Kuiper (1983): rounded shell outline, slight posterior shift of the umbones, relatively short and almost straight dorsal margin, symmetrically placed anterior and posterior lateral teeth. At the same time, the shell of *P. novaezelandiae* is not as convex as that of *P. tasmanicum*, and the umbones are not protruding. Elongation of the presiphonal slit noticeable in the studied New Zealand specimens is another distinctive feature. However, material available for anatomical study is rather scarce and variability of the soft body structure remains unknown. In the typical Eurasian *P. casertanum*, the shell shape is nearly triangular, umbones are strongly shifted posteriorly, hinge plate strongly arched, posterior lateral teeth shorter than anterior ones and presiphonal suture short (Korniushev, 1996). Thus, there are some arguments in favour of species distinctness of *P. novaezelandiae*.

Placement of *P. hodgkini* in the subgenus *Afropisidium* is confirmed. The following significant anatomical characters observed in this species were reported for its consubgenera: absence of the outer demibranch and exhalant siphon (Kuiper, 1962), upper position of the brood pouch, especially on the early stages of its development (Meier-Brook, 1970), dorsally visible lateral loop of nephridium (Korniushev, 1992). Presence of the exhalant siphon retractors in the posterior section of the pedal slit indicates that the latter was merged to the exhalant mantle opening due to reduction of the presiphonal suture, as suggested by Korniushev (1996). Profound weakening of the inner radial mantle muscles distinguishes New Zealand *Afropisidium* from the type species *P. pirothi* Jickely, 1881, the latter species having rather strong bundles of inner radial muscles along the mantle edge (Korniushev, 1998b).

Variability of the shell characters observed in *P. hodgkini* is remarkable. Specimens observed here differ from those described by Kuiper (1966) in their more pronounced sculpture and strongly bent cardinal teeth. The peculiar form found in Waipoa State Forest is larger than the forms described earlier: Kuiper (1966) reported the maximum shell length 4.5 mm. Unfortunately, the available material is not sufficient to trace up geographical pattern of the variability and to test its correlation with ecological factors. However, one may not exclude that more than one *Afropisidium* species currently lives in New Zealand, and the revision of this group seems to be necessary.



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